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Volume 7, Number 2, Spring 1986

Determination of Cr (VI) in Air in the Presence of Cr (III)

Evaluation of Respiratory Impairment in Ontario Pneumoconioses Procedures

Health and Safety of Lab Workers in Canada — A Code of Conduct

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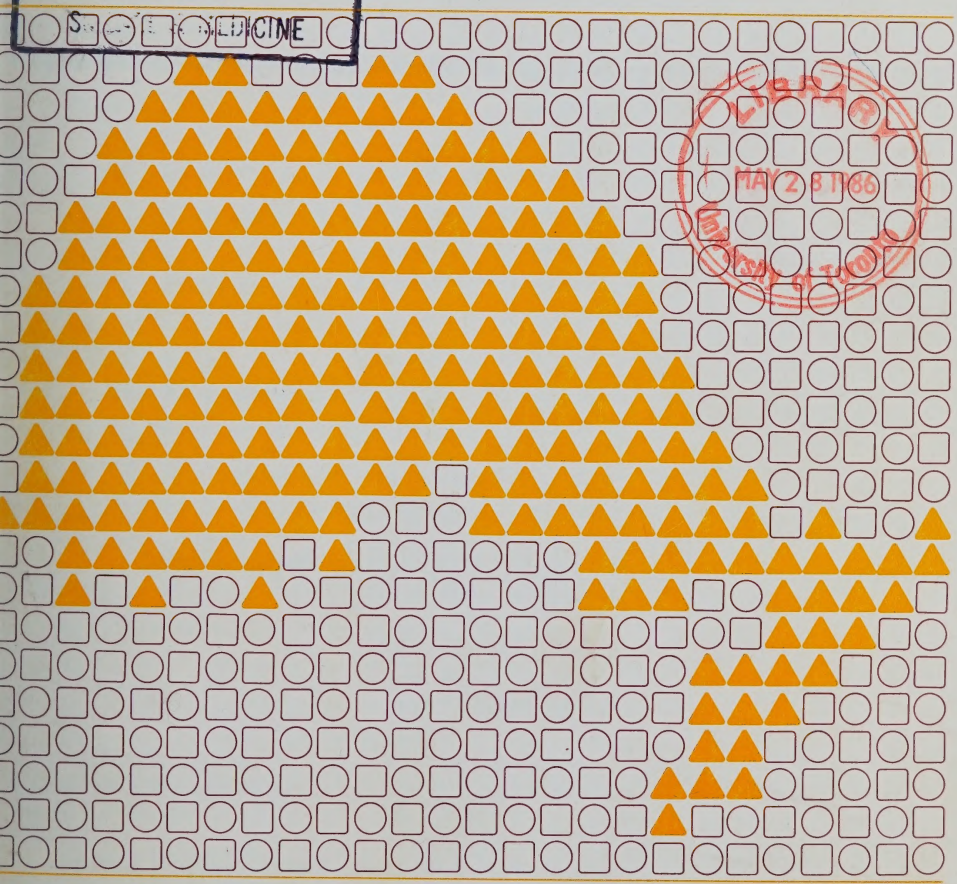

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Occupational Health in Ontario

Volume 7, Number 2, Spring 1986

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1. Lee WR, and Miles S. Postgraduate preparation for occupational medicine. J Soc Occup Med 1976; 26: 115-119.
2. Department of Health and Social Security, Notes on the diagnoses of occupational diseases. Rev ed. London: HMSO., 1972.
3. Gamble JF, and Battigelli MC. Epidemiology. In: Clayton GD and Clayton FE. eds. Patty's industrial hygiene and toxicology. New York: McGraw Hill, 1978: Vol 1; 113-116.

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Correspondence

To the Editor

The article 'A Noise Standard – Evidence Review' by Ihor Taraschuk, M.D., P. Eng., in the summer 1985 issue of this Journal is a curious piece of reactionary policy advice hiding behind 'scientific' solemnity. I put the word 'scientific' in inverted commas because it would only be genuinely scientific if the evidence discussed could be classified as 'pure research'. But research into noise has a practical purpose and application – to protect the hearing of human beings. If the research recommended does not in fact do this – either because it is bad research or because there is no practical mandate to ensure the research is applied – it is a waste of time and brings the scientific foundations of occupational health into deserved disrepute.

The author concludes that we have two options over a noise standard. The first is to do more animal research and then *try* (note the weak implication linking research and policy application) to apply the results to human beings. The second option proposes a regulation but says we need a medical surveillance program to determine whether, in twenty years' time, we need to change the rules. There is no indication that the second option actually proposes any degree of control of noise 'at the source' or whether it is confined to personal protective equipment, medical surveillance, counselling, etc., an all-too-common feature of current noise regulations.

The author concludes that the politicians will have to decide on the options subject to the interpretation of the courts.

What a loaded agenda the politicians are to be presented with! First of all, they are presented with the issues as if all they had to do was to decide on a policy on the basis of certain limited bits of scientific data and the gaps in the evidence required to institute due protection for workers. A third option is, apparently, not to be presented. The option is that we *know* that excessive noise damages hearing; that the more noise people are exposed to, the worse the damage is; that duration of exposure increases the damage; that workplace noise is almost always an avoidable form of pollution; that people do not go to work to have their hearing damaged; and that ways to cut down workplace noise are a matter for far more interested parties than scientists advising politicians.

It is quite true that the evidence for the 3dB rule is limited and that, in any case, statistical data on human hearing loss is unlikely to ape such a simple arithmetical formula linking noise levels to duration of exposure. But it is a simple measurable formula and it has the advantage over the 5dB rule that it offers more stringent protection to workers.

It is also true that interested parties such as workers and employers might offer different opinions as to the relation of noise emissions to noise control. These would be no less unscientific than any arithmetical formula and they would have the enormous and added *scientific* advantage that they concern the real world of work, and not an academic debating society.

But if we do this we have to admit that the grounds for policy-making involve

much more than talking about the effects of noise on rats or the statistical significance of hearing damage on a population of exposed human guinea-pigs. To admit this is to make the point that consultation mechanisms in occupational health and safety are highly unsatisfactory: they turn into talking shops in which the technocrats, physicians and academics go ahead and do their own thing after *years* of 'consultation'. And their own thing, which they do, produces a whole lot of rules that do not *in fact* do anything very much to improve the health of exposed workers. The world is left pretty much as it was before, except that large numbers of drones make a good living out of the taxpayers' pocket and the workers' ill-health. Isn't it about time we spent our energies and limited resources doing things that do actually change conditions of work for the better?

Yours sincerely,
David Bennett,
National Representative,
Health and Safety,
Canadian Labour Congress.

Dr. Taraschuk's response to Mr. Bennett is printed below.

To the Editor

Thank you for offering me the opportunity to respond to Mr. David Bennett's letter to the journal with respect to my article, which appeared in Volume 6, Number 3. I would certainly agree with Mr. Bennett that the evidence on which to base the 3dB rule is limited. I endeavoured to convey these limitations in my paper. With respect to such questions as permissible exposure levels, control programs, evaluation programs, engineering feasibility, employee rights, worker consultations, enforcement and verification of compliance, I would agree with him that these are important issues; however, within the context of what I was endeavouring to convey, within the constraints of space for manuscript in the journal, it was not possible to address these issues, which, I agree with him, are important.

Lastly, I am in complete agreement with Mr. Bennett that attention to the views of individual workers with respect to the effects of workplace hazards on their health is vitally important. It is only by way of a mutual working relationship between occupational health professionals and workers through an ongoing dialogue that health problems related to the workplace can be solved. As I have conveyed in my paper, we are far from having all of the answers with respect to the effects of noise on health and this dialogue will be vitally important if society is to effectively deal with this problem for the benefit of individual workers as well as increasing knowledge with respect to noise, that accumulates over the ensuing years.

Yours very truly,
Ihor Taraschuk, M.D.

To the Editor

I have recently been introduced to your publication which I think is a brilliant idea. Your editorial notice recognizes that errors are possible, and I am happy that I can offer constructive criticism without appearing to be unduly critical.

The article on 'Blood Lead Analysis' (Vol. 4 #6 Fall '85) does not recognize a major (and serious) source of error in the Delves Cup Technique. Lead intoxication leads to varying degrees of anaemia. In a high degree of anaemia (higher intoxication), the population of red blood cells (erythrocytes) is significantly low. When analysed by this technique, the

blood sample will show a lead level which is significantly lower than it actually is.

This source of error has been eliminated by quantifying the erythrocyte population in the blood sample and relating the lead content to both the sample volume and an abnormal red blood count. The procedure is simplified by changing the criterion from wt. of lead/unit volume of blood to wt. of lead/unit weight of blood. The OSHA criteria of the U.S.A. is in terms of μg lead/100 g of blood.

Thank you for the opportunity to participate in your undertaking.

Sincerely yours,
Ramjit Seelagan.

Mr. Walkinshaw's response to Mr. Seelagan is printed below.

To the Editor

The concern of the letter from Mr. Seelagan is that overexposure to lead can cause anaemia and that this condition, coupled with the fact that the red blood cells carry 95 per cent of the lead in whole blood, can in turn give rise to low results for lead in whole blood. The logical conclusion from this is that a good case can be made for assessing lead exposure using packed red blood cells or whole blood with a haematocrit correction. In practice, however, this is not the case and the majority of analytical labs, including such notable ones as the Centres for Disease Control, Atlanta, and the Occupational Medicine and Hygiene Laboratory of the British Health and Safety Executive determine lead exposure using whole blood with no correction for the haematocrit.

The underlying reason for this practice is that an elevated blood lead up to approximately 0.60 mg Pb/L[1,2,3] does not cause any major decrease in the haematocrit. Therefore, a lead level below the regulated action level of 0.70 mg Pb/L would almost always give a blood lead concentration that reflected the true lead exposure.

Also, the Regulation Respecting Lead in Ontario requires a pre-employment medical, including a determination of existing blood disorders; any anaemic condition would be noted. As a further safeguard, the medical code in the regulation requires the physician to enquire regarding work practices and personal hygiene when the blood lead value of a worker rises to 0.60 mg/L, ostensibly to pre-empt a rise in blood lead to 0.70 mg/L. A worker is removed from further exposure when a repeat specimen is confirmed above the latter value.

Whilst I appreciate Mr. Seelagan's valid concerns, the strength of the medical surveillance code of the regulation pre-empts the overexposure that may lead to the haematocrit correction he suggests and substantiates the use of direct blood lead determinations.

1. Kochen and Greenet (1973) Levels of Lead in Blood and Haematocrit. Pediatr. Res., 7: 937-944.
2. Rosen, *et al* (1974) Plasma Lead Levels in Normal and Lead Intoxicated Children. J. Pediat., 84: 45-48.
3. Handbook on the Toxicology of Metals (1979). Pub: Elsevier/North-Holland.

Yours sincerely,
I. Walkinshaw, B.Sc., L.R.I.C.,
Senior Scientist,
Occupational Health Laboratory.

Reimar Gaertner, M.Sc., Galina Moselhy, M.Sc., Douglas Arai, B.A., Mark Nazar, Ph.D., P. Eng., C.I.H.

Determination of Cr(VI) in Air in the Presence of Cr(III)

Summary

A widely used method for the determination of chromium(VI) in air has been evaluated using two different types of filters. Spiking filters with aqueous solutions of chromium compounds resulted in poor recovery with Millipore PVC filters but in good recovery with Gelman PVC filters. On the other hand, when using an atmosphere generator to simulate loading conditions in the workplace, the samples loaded onto Millipore filters were completely recovered but recoveries on Gelman filters were lower than expected. The effect of chromium(III) on chromium(VI) recovery was also studied using the two filter types and loading procedures.

Reimar Gaertner, M.Sc., Occupational Health Laboratory Service, Ontario Ministry of Labour, 101 Resources Road, Weston, Ontario M9P 3T1

Introduction

More than 50,000 workers are occupationally exposed to chromium in Ontario.[1] This exposure occurs in a wide range of industries including: metal plating, welding, pigment manufacture and use, leather tanning, cement construction as well as aircraft and auto manufacture. The chromium encountered in the workplace may be hexavalent chromium [Cr(VI)], trivalent chromium [Cr(III)] or chromium metal and may be bound to a variety of adducts, which affects solubility. Epidemiological evidence, to date, does not permit a clear distinction between the relative carcinogenicity of chromium compounds of different oxidation states or solubilities.[2] Nevertheless, workers in the chromate production industry demonstrate an excess risk of lung cancer.[3,4] Experiments with a variety of animal and bacterial systems have unequivocally shown that chromium toxicity and mutagenicity are exclusively due to the hexavalent ion,[5] most commonly in the form of chromate ion (CrO_4^{2}). Tests with laboratory animals indicate that some relatively insoluble Cr(VI) compounds are carcinogens, notably, calcium chromate, zinc chromate and lead chromate.[2] In similar studies, Cr(III) and highly soluble Cr(VI) compounds did not appear to have carcinogenic activity in animal models.[6]

Oxidation state appears to have a profound influence on the biological activity of chromium, and, therefore, any analysis method should differentiate between Cr(III) and Cr(VI) species. One method is the alkaline carbonate extraction of PVC filters used for air sampling in which the solubilized Cr(VI) is quantified by measuring the absorbance of the blue Cr(VI) – diphenyl carbazide complex.[7,8] This procedure supplants the previously used acid digestion of PVC filters since it was found that Cr(VI) is readily reduced to Cr(III) in an acidic environment.[9,10] Alkaline extraction protects Cr(VI) from reduction to Cr(III) by Fe(II) or other reducing agents, while the carbonate solubilizes otherwise insoluble chromates.[11,12] Recent reports suggest, however, that Cr(III), if present, may be oxidized to Cr(VI) by

atmospheric oxygen during the alkaline extraction process at elevated temperatures.[13,14]

In general, methods are verified by adding a known volume of a solution of a chromium salt to filters (a process called wet-spiking) and testing for complete recovery during analysis. The literature contains several conflicting reports on the stability of Cr(VI) wet-spiked onto various brands of PVC filters.[8,9,15-17] In addition, much of the work on the applicability of the diphenyl carbazide (DPC) method with an alkaline carbonate leach, for Cr(VI) analysis, has only been performed for welding fume, utilizing bulk fume samples.[11,12,18,19] Subsequent addition of clean filters to the bulk fume sample in order to mimic analytical conditions does not effectively test recovery of fume from various filter types.[18]

To further elucidate some of these concerns, it was necessary to assess whether soluble Cr(VI) is stable on PVC filters, using both aqueous spikes and filters loaded by an atmosphere generator. It was also decided to investigate the effects of Cr(III) on Cr(VI) recovery and to compare two types of PVC filters.

Analytical Procedures

Test Atmosphere Generation System

Aerosols of chromium salts were prepared and collected in a three-stage test atmosphere generation system constructed by Stanford Research Institute, California. This dynamic atmosphere generator consisted of: 1) a source generator; using an atomizer, an aerosol of a solution of an appropriate chromium salt ($Cr(NO_3)_3,9H_2O$ or K_2CrO_4) is introduced into the primary tower, wherein the water evaporates; 2) a dilution section; filtered compressed air is mixed with the now dried aerosol at high velocity to produce an atmosphere with a suitable concentration of the analyte; 3) three cone-shaped sampling chambers with 12 sampling ports in each chamber. A three-piece cassette holder with the appropriate filter is attached at each port, and the sampling flow rate through each cassette is controlled by a critical flow orifice installed before a vacuum manifold. The aerosol entering the second and third cones is diluted with air so that the concentration of analyte is approximately one-half and one-quarter respectively of that in the first cone. The loaded filters were stored in the cassettes used for sampling, and the cassettes were stoppered and stored at room temperature pending analysis.

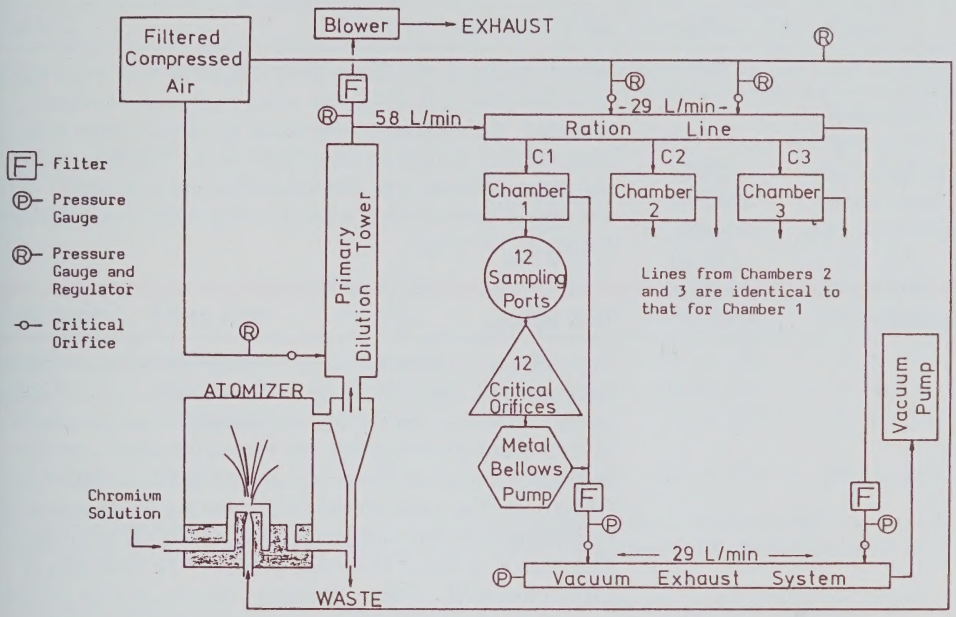

Figure 1 **Schematic of Test Atmosphere Generation System**

The DPC Method

The PVC filters used were supplied by either Millipore (BSWP, 2.0 μm) or Gelman (VM-1, 5μm). All wet spikes were so made that no more than 100 μL of liquid were added to the surface of each filter. The filters were left to dry at room temperature and stored in covered beakers. They were analysed by placing them in beakers and adding 5.0 mL of a 2% NaOH/3% Na_2CO_3 (alkaline carbonate) reagent.

The beakers were covered and placed on a shaking hot plate at 100°C for 30 minutes. After cooling, the contents were transferred quantitatively with water washings to 25-mL volumetric flasks containing 1.9 mL of 6N H_2SO_4, and made up to volume. Following addition of 0.5 mL of 0.25 per cent by weight DPC in acetone/water 1:1, the samples were degassed by sonication until no more gas evolved and the absorbance readings were taken at 540 nm. Standards were prepared using 0.2N H_2SO_4, to which was added the DPC reagent. This method is specific for Cr(VI).

AAS Analysis

Where required, the filters were extracted with aqua regia on a hot plate at 130°C, and when evolution of fumes subsided, the solutions were taken to near dryness and reconstituted in one per cent nitric acid. The total chromium content was determined by flame atomic absorption spectroscopy (AAS), using a rich air-acetylene flame, at 357.9 nm.

Results

Wet Spikes

Tests of Cr(VI) recovery from wet-spiked Millipore filters indicated this filter type may not be suitable for wet-spike studies. Recovery of Cr(VI) was normal when measured several hours after spiking, but recoveries after one day of storage were low and continued to decrease with time (Figure 2). The presence of Cr(III) on the filters appeared to enhance this time-dependent loss of Cr(VI) recovery. This loss was found to be due primarily to reduction of Cr(VI) to Cr(III). Table 1 presents one set of data out of several similar results. Experiment 1 shows that when

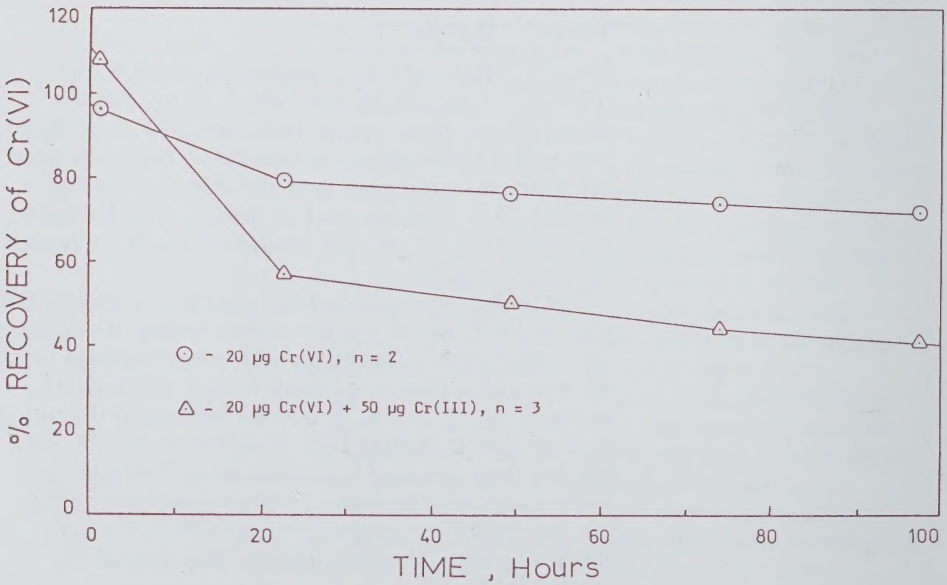

Figure 2 **Recovery of Cr(VI) From Wet-Spiked Millipore PVC Filters. N Equals the Number of Determinations for Each Data Point. The Discrepancy Between Duplicate Determinations Is Always Less Than Five Per Cent**

Table 1 **Recovery of Cr(VI) from wet-spiked PVC filters**

Experiment	Filter type	Extraction solution	Chromium recovered in per cent of total: Cr(VI) by DPC method [Cr(VI) only]	DPC solutions re analysed by AA (soluble chromium)	Extracted filters re-extracted in aqua-regia and analysed by AA (insoluble chromium)
1.	Millipore*	0.2N H_2SO_4	0%	100 ± 3%	3 ± 4%
2.	Gelman**	0.2N H_2SO_4	91 ± 1%	98 ± 4%	1 ± 1%
3.	Millipore*	Alkaline carbonate	33 ± 6%	72 ± 5%	31 ± 5%
4.	Millipore*	Alkaline carbonate	39 ± 2%	47 ± 7%	56 ± 6%

*Millipore filters were spiked with 10 μg of Cr(VI) and stored for three days prior to analysis.

**Gelman filters were spiked with 20 μg of Cr(VI) and stored for three days prior to analysis.

Millipore PVC filters were wet-spiked with 10 μg of Cr(VI), stored for three days and subsequently extracted with acid, all of the Cr(VI) was converted to Cr(III). This high degree of reduction should be compared to a similar experiment using Gelman filters. In experiment two, 91 per cent of the spiked chromium remained in the hexavalent form. The AA analysis indicated seven per cent of the Cr(VI) had been reduced to Cr(III), while one per cent remained on the filter.

When an alkaline carbonate solution was used to extract the aged Millipore filters (experiment 3), 33 per cent recovery was observed. The DPC solution was re-analysed by AAS and was found to contain a further 39 per cent of the total chromium spike, presumably in the Cr(III) form. The remaining 31 per cent chromium initially added remained on the filter, again, presumably as Cr(III). Addition of ethanol to the alkaline carbonate extraction solution (see below) gave essentially the same results (experiment 4).

Stability studies were also carried out using Gelman PVC filters (Figures 3a and 3b). Recovery of approximately 98 per cent of the chromium spike was observed for up to 10 days of storage time. In the

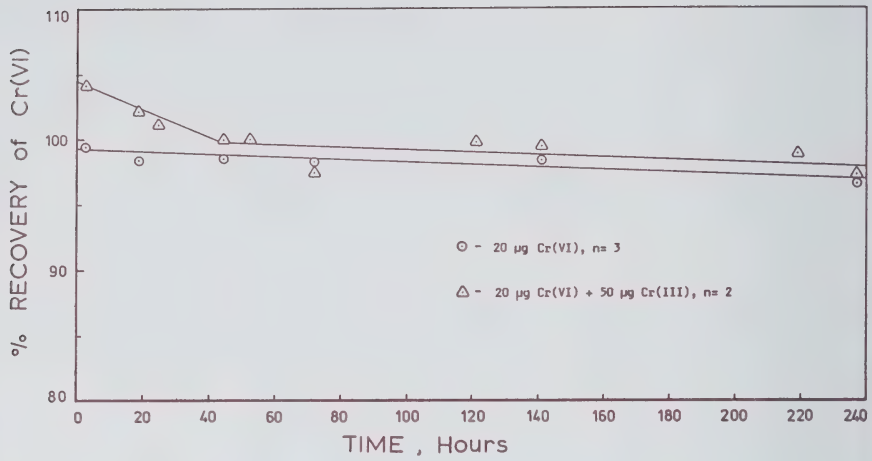

Figure 3a **Recovery of Cr(VI) From Wet-Spiked Gelman PVC Filters. N Equals the Number of Determinations for Each Data Point. The Discrepancy Between Duplicate Determinations Is Always Less Than Five Per Cent**

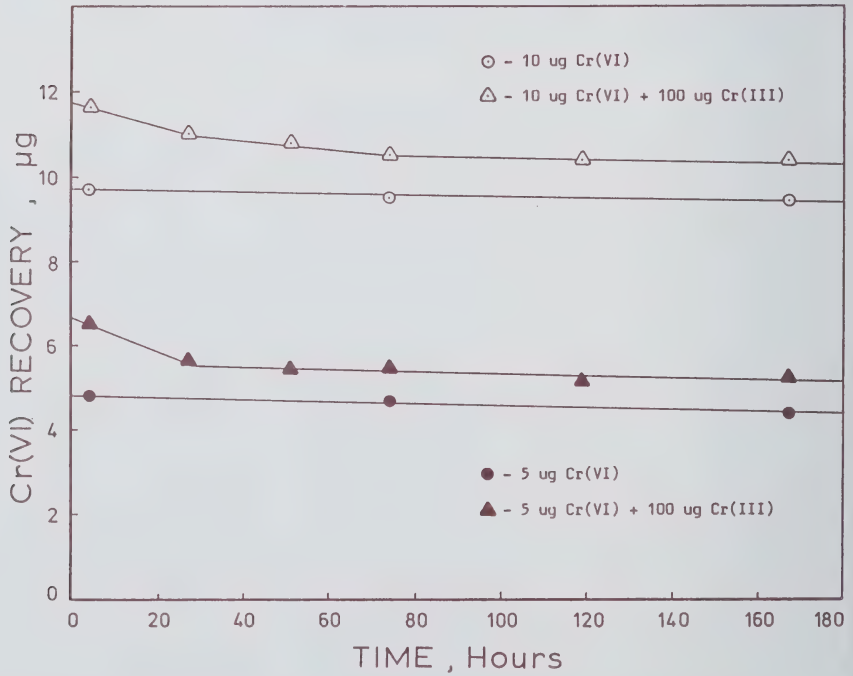

Figure 3b **Recovery of Cr(VI) From Wet-Spiked Gelman PVC Filters Using Ethanol During Extraction. N Equals the Number of Determinations for Each Data Point. The Discrepancy Between Duplicate Determinations Is Always Less Than Five Per Cent**

presence of 50 or 100 μg of Cr(III), the recovery of 5, 10 or 20 μg of Cr(VI) was significantly elevated when measured several hours after spiking. After two or three days' storage, however, the positive interference of Cr(III) on Cr(VI) recovery decreased noticeably.

Atmosphere Generation

The studies of Cr(VI) recovery from Millipore and Gelman filters were repeated using the atmosphere generator (AG) in lieu of wet spikes to load the filters. Figure 4 shows that the recovery of Cr(VI) from Millipore filters loaded by the AG was approximately 99 per cent within the first two days. The recovery of Cr(VI), with or without Cr(III), was similar to that for Gelman filters loaded by wet-spiking (Figures 3a and 3b).

When Cr(VI) was loaded by the AG onto Gelman PVC filters, recoveries were consistently low and erratic (Figure 5). These low recoveries were found to be due to

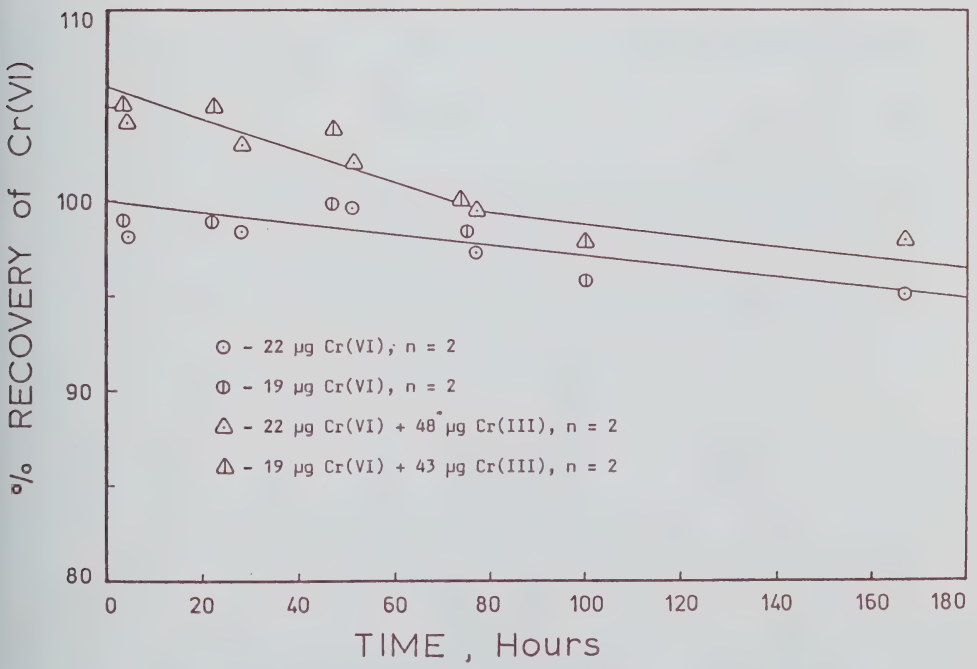

Figure 4 **Recovery of Cr(VI) From Millipore Filters Loaded by an Atmosphere Generator. N Equals the Number of Determinations for Each Data Point. The Discrepancy Between Duplicate Determinations Is Always Less Than Five Per Cent**

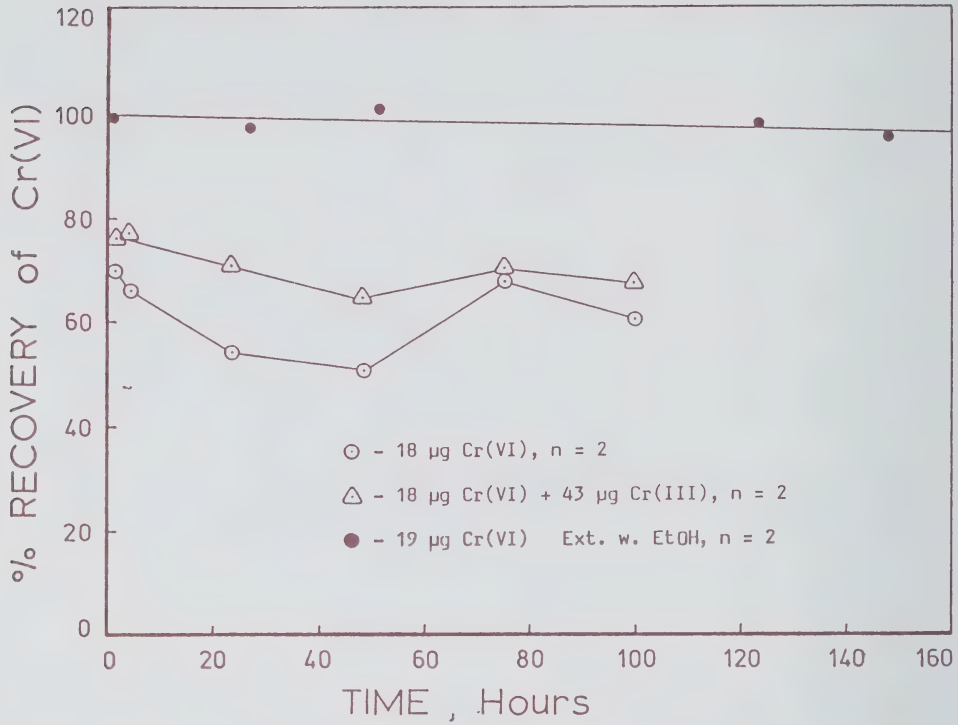

Figure 5 **Recovery of Cr(VI) From Gelman Filters Loaded by an Atmosphere Generator. N Equals the Number of Determinations for Each Data Point. The Discrepancy Between Duplicate Determinations Is Always Less Than Five Per Cent. The Data for Gelman Filters Extracted Without Ethanol Show a Variance of Up to 10 Per Cent**

incomplete extraction of Cr(VI) from Gelman filters. In every case, the remainder of the chromium not found in the DPC procedure was recovered by acid extraction of the filters by AAS analysis.

In an attempt to completely extract Cr(VI) from Gelman filters, these filters were wetted with 1.0 mL of 95 per cent ethanol before addition of 5.0 mL of alkaline carbonate extraction solution. This procedure has no effect on the colour development of standards or blanks. As shown in Figure 5, this procedure was successful in increasing the Cr(VI) recovery from Gelman filters to that observed for Millipore filters without addition of ethanol. Using this technique, loaded filters showed Cr(VI) recoveries of greater than 90 per cent for more than 16 days of storage time. These results have been summarized

Table 2 **Per cent recovery of Cr(VI) on two filter types***

Filter Type		Recovery	
		Wet Spike	Atmosphere Generator
Millipore (hydrophyllic)	analysed immediately	95.5 ± 0.6	98.6 ± 0.5
	aged for 3 days	74 ± 2	97.6 ± 0.8
Gelman (hydrophobic)	analysed immediately	99.4 ± 0.1	71 ± 6
	aged for 3 days	98.3 ± 0.3	65 ± 9
Gelman (hydrophobic with ethanol added)	analysed immediately	97.2 ± 0.5	98.9 ± 0.5
	aged for 3 days	96.6 ± 0.7	97.8 ± 0.5

*Approximately 20 μg of Cr(VI) were used in each experiment.
Each experiment is the average of 2-6 determinations.

in Table 2. Further tests indicated that 250 μL of a 1:1 aqueous dilution of acetone or dioxane may be used instead of ethanol. The latter can react with Cr(VI) to form an organo-chromium compound in strong acid solutions.[20] Under the assay conditions used, ethanol caused a reduction in recovery of 5.0 ± 0.5% when 5 μg of Cr(VI) was analysed. No loss was observed when using acetone or dioxane.

Discussion

The recovery of Cr(VI) from Millipore PVC filters spiked with aqueous solutions of chromate decreases with time (Figure 2). The decrease in Cr(VI) recovery is due primarily to reduction of Cr(VI) to Cr(III) on Millipore filters during storage or the extraction process. Table 1 indicates that approximately 40 per cent of the chromium remains in the hexavalent state after storing the filters for three days (experiment 4). Nonetheless, even this Cr(VI) must be in a form more sensitive to reduction since a dilute acid solution readily converts all of the Cr(VI) to Cr(III) (experiment 1). This compares to only eight per cent reduction when using Gelman filters in a parallel test (experiment 2).

Recovery experiments using Gelman filters showed good recoveries for over 10 days of storage time (Figures 3a and 3b). However, the wet-spike procedure may artificially favour the Gelman filters over Millipore since these two brands of filters are very different in hydrophilicity. The Gelman filters repel water, as might be expected from PVC. Aqueous spikes on these filters bead up and dry in a concentrated spot, effectively isolated from contact with the filter. The Millipore filters, on the other hand, were found to absorb wet spikes right into the filter.

Using an atmosphere generator, both types of PVC filters were loaded with Cr(VI) and Cr(III) particles (less than 0.5 μm diameter) in a relatively dry atmosphere (approximately 20 to 30 per cent RH). Results, using this more realistic loading protocol, indicate that Cr(VI) loaded onto Millipore filters is stable for more than seven days, with recoveries better than 95 per cent (Figure 4). It is not clear why Cr(VI) wet-spiked onto Millipore filters is reduced to Cr(III), while Cr(VI) loaded onto the same filters using an atmosphere generator under essentially dry conditions, results in good recoveries. It may be speculated that the filter matrix is involved in the reduction process. Thus, intimate contact of Cr(VI) with the filter would favour reduction. This would explain the dramatic reduction of Cr(VI) on wet-spiked Millipore filters, where intimate contact with the filter matrix would be high. This degree of contact would not be expected with the hydrophobic Gelman filter, nor when loading filters with 'dry' Cr(VI) particles.

The recovery of Cr(VI) from Gelman filters loaded by an atmosphere generator was very poor (Figure 5). It may be that, because of the loose-weave nature of these filters and the very small particle size of the Cr(VI) aerosol, a significant degree of particle penetration into the interior of either filter type could be expected. Since Gelman filters repel water, the aqueous alkaline carbonate solution may not penetrate the filter sufficiently to properly extract deeply embedded particles. This argument is strengthened by the finding that addition of ethanol, to wet the Gelman filters during extraction, results in Cr(VI) recoveries better than 95 per cent after more than 10 days of storage (Figure 5). Smaller quantities of acetone or dioxane will also wet the filters while giving a slightly higher recovery. Presumably, recovery is slightly lower with ethanol due to formation of an organo-chromium complex in the dilute acid solution of the developed samples.

The recovery of Cr(VI) in the presence of Cr(III) was

examined at several levels of Cr(VI) and Cr(III) (Figures 3a, 3b and 4). When recoveries of Cr(VI) were normal, recovery of Cr(VI) with Cr(III) was elevated after several hours of storage whether the filters were loaded by an atmosphere generator or wet-spiked. This positive interference decreased with time and eventually became constant so that 100 μg of Cr(III) caused a five per cent positive error when analysing 10 μg of Cr(VI). The chemistry of this ageing phenomenon is not understood at present. This positive interference appears to depend solely on the Cr(III) concentration up to a limit of approximately 100 μg. The percentage interference will be more significant at lower Cr(VI) levels, and special precautions to avoid Cr(III) oxidation, such as extraction in an inert atmosphere[13] or addition of magnesium salt[14] may be required. Chromium(III) interference is observed only when a Cr(III)/Cr(VI) mixture is heated in an alkaline medium. The DPC method is otherwise very selective for Cr(VI) over Cr(III) when analysed directly.

This report confirms the results presented for NIOSH Method No. 7600[8] in that Cr(VI) wet-spiked onto Millipore filters is not stable. Other conflicting reports may be attributable to various extraction solutions and filter types used.[15-17]

Conclusions

The results of this study indicate that Millipore filters are unsuitable for wet-spike studies of Cr(VI) recovery since Cr(VI) is converted to Cr(III) after storage and extraction. These filters are, however, well suited for air sampling of Cr(VI).

Gelman filters, on the other hand, while useful for wet-spike studies, give poor recoveries of Cr(VI) when loaded by an atmosphere generator. Complete extraction of soluble Cr(VI) particles from Gelman filters is possible if a wetting agent is added to the alkaline carbonate solution.

Chromium(III) causes a positive interference on Cr(VI) recovery when Millipore or Gelman PVC filters were analysed immediately after loading or spiking. This interference decreases significantly when the filters are stored for two to three days prior to analysis.

Résumé

On a évalué une méthode couramment employée pour déterminer la présence de chrome hexavalent dans l'air à l'aide de deux types de filtres. La récupération au moyen de filtres imprégnés avec des solutions aqueuses de composés de chrome a donné de piètres résultats avec les

filtres Millipore PVC mais de bons résultats avec les filtres Gelman PVC. D'autre part, en employant un générateur d'atmosphère pour simuler les conditions de saturation en milieu de travail, les échantillons utilisés avec les filtres Millipore ont été entièrement récupérés alors qu'avec les filtres Gelman la récupération a été beaucoup plus faible que prévue. On a également étudié les effets du chrome trivalent sur la récupération du chrome hexavalent à l'aide des deux types de filtres et de méthodes d'imprégnation.

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Evaluation of Respiratory Impairment in Ontario Pneumoconioses Procedures

Summary

The Advisory Committee on Occupational Chest Diseases was formed as an independent medical panel in 1927 to examine pneumoconiosis claimants referred by the Workers' Compensation Board of Ontario. It has a mandate to provide expert opinion on the evidence for occupationally induced lung disorders and estimates any resulting medical impairment. This article reviews the procedures and references used by the committee to arrive at its recommendations.

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It was first realized in 1924, following a report by Dr. J.H. Elliott on 11 Porcupine area gold miners, among whom he found three cases of silicosis,[1,2] that pneumoconiosis was a problem in Ontario miners. The first case was compensated in the same year on medical evidence submitted by Dr. C.D. Parfitt. During the following five years, other authors, as well as the provincial Industrial Hygiene Division of the Ministry of Health, reported numerous other workers with silicosis and described their pathologic findings.[3,4,5,6,7,8]

The Ontario approach to silicosis was influenced, at first, by that of South Africa, which, having opened its own gold fields in the 1880s, already had considerable experience with the disease and had appointed a Medical Bureau in 1916 to do both surveillance and follow-up diagnostic examinations on its underground miners.[9]

In 1917 'miners' phthisis', a combination of silicosis and tuberculosis, became recognized under the *Workmen's Compensation Act of Ontario* as the first compensable industrial disease resulting from dust inhalation. Stone workers' or grinders' phthisis (silicosis and tuberculosis) from the quarrying, cutting, crushing, grinding or polishing of stone or metal was included in 1925. Silicosis in mines was added to the Industrial Disease schedule of the *Workmen's Compensation Act* on April 8, 1926, from which date the Workers' Compensation Board (WCB) has made awards for compensation, and, in June 1926 non-tuberculous pneumoconiosis was added to the same processes in which stone workers' and grinders' phthisis were already compensable.[10]

In 1927 Dr. J.M. Smith of the South African Miners' Phthisis Medical Appeal Board was invited to Canada by the Ontario Department of Mines (upon the suggestion of the Ontario Mining Association) to advise on compensation for the new diseases. After extensive local study and teaching, Dr. Smith recommended the formation of a Silicosis Referee Board, which was to report only to the WCB and be administered by it. He felt that the board should have three members, the majority decision being binding. Local doctors, upon finding a worker with suspected silicosis, were to

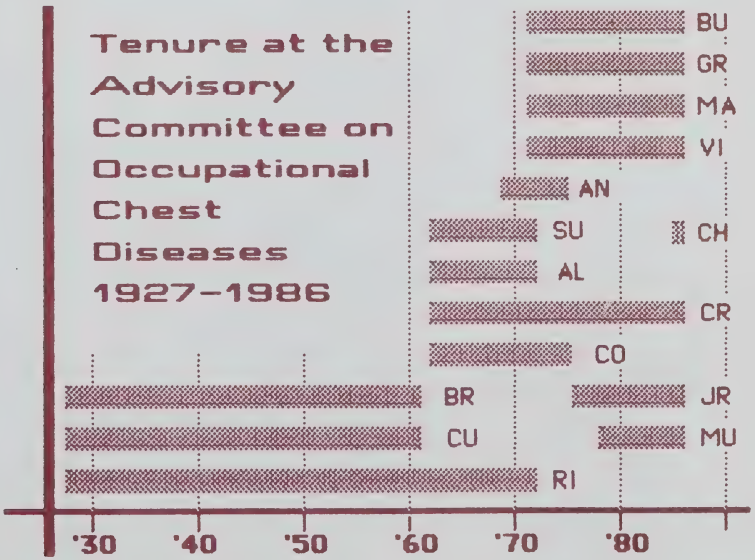
refer his claim to the WCB, which determined whether the claim met minimum exposure requirements for compensation and then asked the Silicosis Referee Board to conduct its own examination and chest X-rays.[11] The three original members were Drs. Cunningham, Brink and Riddell, from the Ontario Department of Health, all recommended by Dr. Smith as being the most qualified in Canada.

In April 1928 the *Mining Act* was amended to provide for pre-employment and regular annual examinations of miners by physicians of the WCB and also for issuance of a 'Certificate of Freedom from Tuberculosis of the Respiratory Organs.' This provided both a system of medical surveillance for workers and a continuing inflow of cases of silicosis to the board from the northern mining areas of Ontario.

During the Silicosis Referee Board's first 40 years of existence, the pattern of pneumoconiosis gradually changed, and the board's name eventually led to some misunderstanding of its function. Therefore, it was renamed the 'Advisory Committee on Occupational Chest Diseases' (ACOCD) on November 29, 1968 to reflect its legal and functional role more accurately.

From 1927 to the present, this panel's terms of reference have extended only to diagnosing pneumoconiosis and estimating the degree of impairment

Figure 1



resulting from it. Its authority never extended to the question of entitlement to compensation even though its recommendations have, in fact, usually been followed.

Between 1927 and 1986, a total of 15 physicians have served on the panel. The original three members served together for the first 34 years, and one of them continued for a total of 45 years. During the last 25 years, 13 physicians have served as members of the committee (Figure 1).

Evolutionary Advances

Today's methods of establishing compensation levels have changed in response to the emergence of new occupational syndromes and diagnostic innovations, in step with similar changes in all of medicine. Pneumoconiosis is now readily diagnosed at an early stage, well before the onset of symptoms and any measurable functional impairment. Employees and employers now co-operate to minimize dust hazards at the workplace, and the reduced severity of disease is reflected in generally lower impairment levels at the time of first diagnosis. For these reasons, there is now seldom much progression of impairment after initial assessment.

Occupational asthma has become an important health problem. Claims for this group of disorders, as well as for the acute illnesses caused by inhaling toxic fumes, are adjudicated internally at the WCB by its own medical consultants and usually not by the ACOCD. On occasion, however, the committee is asked to do physiologic studies for these problems or to provide opinion on outside investigations.

Thus, the main role of the ACOCD is to provide a consistent record of the exposure histories, physical signs and functional impairment of workers with pneumoconiosis and to re-examine them regularly, recommending higher impairment ratings when indicated. Two important additional tasks involve evaluating posthumous claims and assessing whether a worker currently in fibrogenic dust exposure should be advised to change his or her job in an attempt to prevent the advance of an occupational respiratory illness.

Present Range of Diseases

The commonest pneumoconiosis seen at the ACOCD is still simple nodular silicosis. Most new cases now come from the surface industries, but a large elderly population of ex-miners, some of whom are well into their eighties,

is also followed, usually at two or three-year intervals. Another large group of workers under surveillance, now nearing retirement age, contracted silicosis of an accelerated type at Ontario's Elliot Lake uranium mines, and in the 1970s the asbestos-related syndromes added a smaller, but still substantial, group for follow-up. More uncommon disorders, such as the cobalt-related respiratory diseases and those of former European coal-workers who continued to work after the war years in Ontario mines, complete the majority of types of disease seen at the ACOCD.

Table 1 lists the range of occupationally and non-occupationally induced lung disease that has been evaluated by the committee. Most referrals involve pneumoconiosis, defined as the lung's pathologic reaction to inhaled dust particles. Thus, silicosis, asbestosis and, elsewhere in the world, coal workers' pneumoconiosis, represent common examples of this form of chronic lung disorder. Although some of the listed diseases are not pneumoconioses, they have involved unusual physiologic patterns and were referred for this reason. Most, but not all, of the disorders seen represent compensable conditions. (Table 1)

Work Removals

'Work removals' represent a recent addition to the work of the ACOCD. The silica and asbestos regulations under the *Occupational Health and Safety Act* require an examining physician to consult with the senior chest physician of the Ministry of Labour and a rehabilitation officer of the WCB before recommending the removal of an employee from work that involves the inhalation of fibrogenic dust.[12] This consultation starts an accelerated claim procedure at the WCB and referral to the ACOCD. The latter reports whether it believes that the work removal is justified, and with this recommendation in hand, the WCB Claims Adjudication Branch and Medical Service decide whether to support the worker if the work removal should entail any financial losses. The decision is then sent to the referring physician as soon as possible.

Logistics of Examination

The ACOCD personnel includes eight physicians, two serving as internal medicine and occupational medicine consultants, a consultant pathologist and a clerical secretary. A pulmonary function technologist and rotating radiologic technologists from the Ministry of Labour perform the technical studies.

A claim can be started by any person, whether a

Table 1 **Occupationally Related Conditions:**

Silicosis
Silicosis with progressive massive fibrosis
Silicotuberculosis
Sandblasters' silicoproteinosis
Asbestosis
Asbestos-related diffuse pleural thickening
Pleural plaque formation due to asbestos or tremolite exposure
Malignant pleural mesothelioma
Bronchial carcinoma related to asbestos exposure
Laryngeal cancer related to asbestos exposure
Gastrointestinal cancer related to asbestos exposure
Thoracic crush injury
Occupational asthma
Nepheline syenite pneumoconiosis
Shaver's disease (Bauxite ore pneumoconiosis)
'Talc' pneumoconiosis
Tremolite-related pulmonary parenchymal fibrosis
Berylliosis
Hard metal disease (cobalt-tungsten carbide related)
Subacute alveolitis (cobalt-tungsten carbide related)
Mushroom pickers' disease
Maple bark strippers' disease
Coal Workers' Pneumoconiosis (CWP)
CWP complicated by hard rock mine silica exposure
Uranium-silica mixed dust exposure
Asbestos-silica mixed dust exposure
Histoplasmosis

Special evaluations for suspected occupational causation:
Toluene di-isocyanate exposure
Industrial solvent exposure
Diesel fume exposure

Non-occupational pulmonary conditions that may be seen together with the above occupational diseases:
Chronic airflow limitation
Asthma
Sarcoidosis
Tuberculosis
Rheumatoid lung

physician, employer, co-worker or the employee himself or herself. Only a note explaining the problem and identifying the claimant needs to be sent to the Medical Department of the WCB, at 2 Bloor St. East, Toronto, Ontario, M4W 3C3. A routine claim investigation is then initiated, and further instructions are given. However, it should be understood that a worker is also free *not* to start a claim if he or she so wishes. After passing an enquiry of eligibility criteria for dust or fume exposure in Ontario, the claim is referred to the ACOCD for pneumoconiosis or to the WCB specialist for asthma evaluation. Initial appointments are usually held in the Toronto office, where full pulmonary function laboratory technology is available, whereas the periodic re-examinations are more commonly done near the claimant's home at a centre that has facilities for chest X-rays and spirometry. The WCB pays for the cost of transportation, lodging, meals and examinations.

Following physical examination by a chest specialist, X-rays and pulmonary function tests, the claim is reviewed at a weekly meeting of the members of the ACOCD. A report representing the consensus of opinion of the whole committee is sent to the WCB, which may then also consider additional factors that could indicate a higher rating than that recommended for the loss of lung function only. If any additional information is required, the committee has powers under the *Workers' Compensation Act* to request this directly from the source.[13] While the claims review must remain entirely confidential, physicians with an interest in the proceedings of the committee are welcome to attend if a prior appointment is made.

Legal Aspects of Impairment Evaluation

The panel considers two essential questions:

1. Is an occupational respiratory disease present?
2. If so, is there any resulting loss of lung function?

If a chronic occupational respiratory disease is thought to be present, a follow-up by the ACOCD for the lifetime of the claimant is offered. At subsequent re-examinations, the impairment rating may be increased because of progression of the condition or its more definite manifestation, even if compensation was not awarded initially. The occupational disease is diagnosed on the basis of all that is known to the members of the panel and/or described in the world medical literature on the condition in question. If, as often happens, a non-

occupational respiratory disease is present in addition, the best estimate possible is made of the relative contribution of each, as well as of their combination, to the total impairment of the claimant. During its deliberations, the ACOCD considers carefully all information available on the hazards found at a particular worksite through inspection visits by the Ministry of Labour or the WCB. Similarly, the results of epidemiological studies, both local and world-wide, of worker exposure are taken into account.

But the presence alone of a disease does not entitle a worker to compensation. Under the *Workers' Compensation Act, Revised Statutes of Ontario, 1980*, Chapter 539, section 122(1), it is stated:

> Where a worker suffers from an industrial disease *and is thereby disabled* . . . and the disease is due to the nature of any employment in which he was engaged, whether under one or more employments, the worker or his dependants are entitled to compensation . . . .[14]

The *Occupational Health and Safety Act*, although it is not directly applicable to the ACOCD mandate, offers a similar statement:

> 'Occupational illness' means a condition that results from exposure in a work place to a physical, chemical or biological agent *to the extent that the normal physiological mechanisms are affected and the health of the worker is impaired thereby* and includes an industrial disease as defined by the *Workmen's Compensation Act*.[15]

The emphasis in each of the quotations above is the author's and serves to point out the fact that the ACOCD's task is to recommend compensation if there is evidence of impairment – but not if there is the mere presence of disease. Under certain circumstances, individuals with radiological disease but no functional impairment may take advantage of the board's Special Rehabilitation Program (SRP).

It is interesting to note that in the United States, medical impairment, meaning loss of function, is determined by physicians, but disability, meaning impairment plus socio-economic and employability factors, are determined by judges in court. While the Ontario system does not routinely involve the courts, a parallel does lie in the assessment of impairment by the ACOCD and of disability by the WCB.

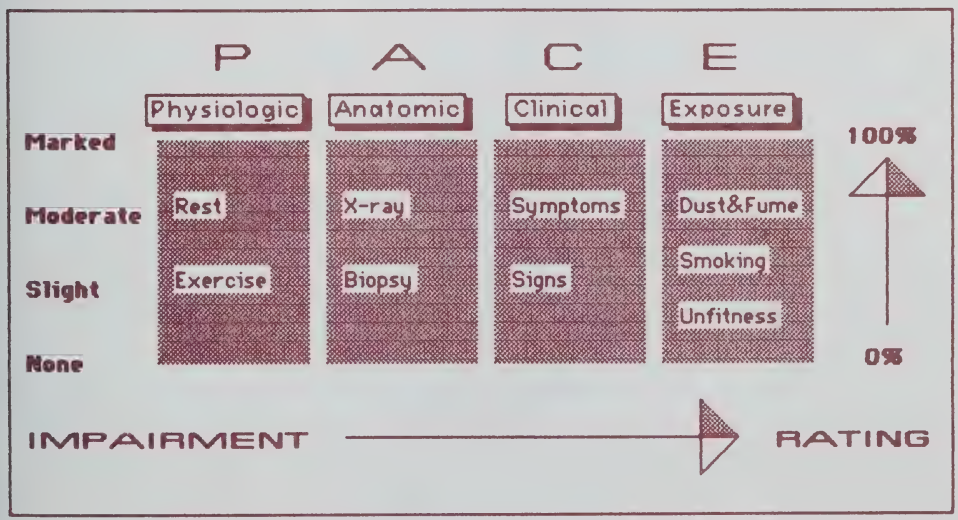
Determining Impairment: the 'Pace' Diagram

Although the committee does not follow a rigid sequential procedure in its discussions, it is helpful to think of the process of impairment evaluation as following the sequence, Physiologic – Anatomic – Clinical – Exposure, which makes the acronym PACE[16] (Figure 2).

Usually, the evidence is presented in the reverse order: ECAP. At first, all data regarding hazardous substance exposure for a claimant are reviewed. This falls under the general heading 'Exposure'. Detailed dust counts as well as past incidence of occupational disease in a given plant and in the industry are considered. This heading does include confounding elements as well: Cigarette smoking is a well-known cause of impaired lung function, and many feel that it may aggravate the effect of dust and fume inhalation. Unfitness is an equally likely basis for reduced exercise tolerance and breathlessness on exertion – the almost universal complaint of patients who are seen at the ACOCD. These factors are considered and can fairly easily be classified into 'none', 'slight', 'moderate' or 'marked' categories, based on the experience of the members of the committee.

The 'Clinical' symptoms and signs noted at the committee's examination, as well as those recorded by other physicians, are next to be taken into account. Usually, they fall into two classes: those related to

Figure 2



occupational exposures and those related to co-existing non-occupational conditions. The findings are distinguished as much as possible, giving due regard to any additive or multiplicative health effects that could occur. If serious doubt occurs about the significance of an abnormality, the committee decides in favour of the claimant. While the estimation of psychological, socio-economic and employability problems that could result from the diagnosis of an occupational disease is not within the mandate of the ACOCD, the committee does report its opinion of such matters if they are relevant.

'Anatomical' evidence usually consists of chest X-rays, sometimes with special views or other diagnostic imaging techniques; sometimes there is available pathological information from a lung biopsy. All the information is considered fully and, when doubt or controversy exists, the pathological slides, if available, are reviewed by the consultant pathologist. In general, though, the committee discourages the use of lung biopsies if done only for the sake of advancing the claim since claimants often suffer unduly, without proportionate claim advantage, from the complications of the biopsy itself. A biopsy is more properly indicated in an attempt to diagnose a medically or surgically treatable condition that cannot otherwise be ruled out.

The committee receives most valuable help for its decisions from its pathologist. Postmortem pathologic material from Northern Ontario miners is frequently sent by local medical staff for review by the committee. If pneumoconiosis is diagnosed from such pathologic studies, and there is evidence, even in retrospect, that there was loss of lung function or clinical disability resulting from the disease, consideration is given by the WCB to posthumous compensation to the family of the deceased.

The chest X-rays are interpreted with reference to the International Labour Office (ILO) 1980 classification of radiographs of the pneumoconioses.[17] In addition, the X-rays are also categorized by the 'Ontario Code', a reporting system that evolved from a South African radiologic classification of the 1930s and is expressed by the numerals one to six. This is the coding that is sent to the WCB, and, under its current interpretation, it simply expresses whether no evidence of pneumoconiosis is seen on the X-ray, whether it is possibly or definitely present or whether it is advanced. The dual recording makes it possible to interpret X-rays according to current worldwide standards while also maintaining continuity

with the vast collection of previous reports held by the WCB.

The ILO 1980 classification was incorporated by the Ontario Ministry of Labour in its designated substances medical surveillance program in September 1983, when suitable computer services became available. In adjudicating difficult films, the ACOCD has used earlier forms of the ILO classification since 1957, and it incorporated the most recent version into its routine readings in July 1985. Its members belong to the Canadian Pneumoconiosis Reading Panel in order to assist in maintaining a standard reading level.[18]

In most matters, the practice of the ACOCD follows recommendations made by the Canadian Task Force on Occupational Respiratory Disease (Pneumoconiosis) in 1979.[19] The radiographic category usually accepted as consistent with pneumoconiosis is ILO 1980 category 1/1 or greater for small opacities of the p,q,r, or s,t,u type. This is summarized as 'Code 5' or 'Code 6' in routine reports to the WCB, depending on the degree of progression. Category 1/0 opacities fall into a borderline area from which about 50 per cent of cases later develop pneumoconiosis. This appearance is termed 'dust effects' or 'Code 4', and lesser radiographic appearances, called 'Code 1' to 'Code 3', are considered to be normal. Slight variation occurs from reading to reading, depending on differences in X-ray technique between examinations.

The 'Physiological' evidence encompasses all functional tests done at rest and on exercise and they are done according to methods and reference values recommended by the American Thoracic Society[20,21,22] as well as the American College of Chest Physicians.[23] Most frequently, this implies a battery of pulmonary function studies done at rest: forced expiratory spirometry, static lung volumes measured with body plethysmography, gas transfer factor (single breath diffusing capacity), and maximal inspiratory and expiratory pressures. Patients with obstructive ventilatory defects are further tested with bronchodilators to assess the response to these agents and the degree of reversibility of the obstruction. The tests are summarized and followed on flow charts that highlight tendencies to change. A baseline established at the first examination is used as reference for the follow-up studies in peripheral centres, where often only the less tiring and time-consuming forced expiratory spirometry is available. If more detailed investigations are required, the claimant is re-examined in Toronto.

Breathlessness on exertion is the commonest presenting

complaint in all claimants for pneumoconiosis, and tests are also done at an appropriate level of exercise, unless contra-indicated by findings such as abnormal ECG, a significant history of symptoms of heart disease, locomotion problems, intermittent claudication of the legs, etc. If the test is unlikely to yield additional useful information, it is not conducted.

All the results of the above investigations can be classified into the 'none' to 'marked' categories, using appropriate definitions, and the integration of them all leads to a final impairment rating. It is difficult to develop a reliable index that would lead to a precise rating for all claimants because human judgement and consideration of the whole person is an important part of the process, and this is very subjective. Since the accuracy and reliability of the data derived through the PACE sequence are also quite variable, each of the factors needs to be weighted by the members of the committee. The evaluation process is, in practice, easier than its description, but its effectiveness and value depend on the continuity and experience of the members. Overall, the ratings given have been consistent in defining the spectrum of impairment among claimants, and the members seldom differ in their assessments by any substantial degree.

Concurrent non-occupational respiratory disease is the biggest assessment confounder for the ACOCD. Very often, impairment from the non-occupational factor is greater than that from the occupational one; yet, only the total impairment concerns the claimant. If, in such situations, occupational factors play even a minor role in the diagnosis, it is understandable that resentment by the claimant may ensue when compensation cannot be paid under the current statutes in proportion to the total disability.

If an appeal is launched, the case before the ACOCD is reviewed by the full membership.

Guidelines in the *Workers' Compensation Act*

The most recent edition of the *Workers' Compensation Act* gives clear guidance to those asked to evaluate claims.[24] It states that:

> . . . In determining any claim under this Act, the decision shall be made in accordance with the real merits and justice of the case and where it is not practicable to determine an issue because the evidence for or against the issue is approximately equal in

weight, the issue shall be resolved in favour of the claimant.

Thus, the WCB asks the ACOCD to make a diagnosis of occupational illness based upon its estimate of the *probability* that the condition is caused by workplace toxins or dust. Probability is established with a half-and-half likelihood that the workplace environment has been at fault. The *possibility* of workplace causation, estimated as a clearly less-than-equal chance, is not sufficient for the purposes of the WCB to establish a diagnosis of occupational respiratory disease.

Résumé

Créé en 1927 à titre de groupe médical autonome, le Comité consultatif sur les maladies pulmonaires professionnelles est chargé d'examiner les demandes d'indemnisation relatives aux pneumoconioses que lui renvoie la Commission des accidents du travail de l'Ontario. Il a pour mandat de fournir des avis spécialisés quant aux preuves présentées sur les causes professionnelles des troubles pulmonaires, et il évalue tous les troubles médicaux qui peuvent en résulter. Cet article examine les méthodes que le comité emploie pour élaborer ses recommandations.

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Health and Safety of Lab Workers in Canada – A Code of Conduct*

Summary

The Federal-Provincial Advisory Committee on Environmental and Occupational Health, recognizing that laboratory workers are exposed to higher health risks than previously considered, established the Working Group on Health and Safety of Laboratory Workers. *This report is the result of the deliberations of the Working Group, who met between October 1982 and October 1983. It is hoped that this code of conduct for laboratory workers will outline for all personnel the general terms of references for improved health and safety in the laboratory.*

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Terms of Reference

The terms of reference for the Working Group on Health and Safety of Laboratory Workers were:

a) to develop a code of conduct outlining broad guidelines for laboratory operations relating to health and safety;
b) to identify ways and means of implementing the code of conduct;
c) to identify means whereby the practice of the above code of conduct can be monitored, with initial attention to governmental laboratories; and
d) to develop, within the code of conduct, a plan for the collection of data relating to the health and safety associated with the laboratory.

Introduction

The purpose of this section is to provide background information on a number of elements of laboratory health and safety in Canada. These elements, which help set the framework for a code of conduct, consist of:

1. Safe working conditions
2. Identification of hazards
3. Classification of potential health hazards
4. Co-operation
5. Education
6. Environmental monitoring in the laboratory.

1. Safe Working Conditions

Many factors contribute to hazards or the control of hazards in the laboratory workplace:

- type of bench surfaces
- amount and type of ventilation

* A report from the Working Group on Health and Safety of Laboratory Workers to the Federal-Provincial Advisory Committee on Environmental and Occupational Health.

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- adequacy of electrical wiring
- type of floor surfaces
- presence/absence and suitability of fume hoods
- amount of illumination
- availability of first aid stations, eye washes, fire blankets
- adequacy of precautions or facilities for explosive hazards
- availability/suitability and use of protective clothing, e.g. laboratory coats, shoes, gloves and aprons
- degree and training of personnel in fire prevention and first aid
- availability of appropriate expert advice within the laboratory

The liability in respect to unsafe working conditions rests with the employer, while the responsibility for working safely rests with the employee.

2. Identification of Hazards

Health and safety committees should be active in identifying and eliminating hazards. All workers should be encouraged to be critical of their own work practices and to discuss their concerns with supervisors. Recognition of potential hazards must become a habit and be developed through education. There is a need to provide new employees with specific information relating to the type of work procedures they will undertake.

A worker's supervisor should be responsible for discussing potential hazards with the worker; however, both supervisor and employee should have full access to the health and safety committee in the event of unresolvable differences of opinion on health and safety matters.

Health and safety committees may need to be concerned with remedies for deficiencies in building design or maintenance. Co-operation between the engineering and maintenance staff and the health and safety committee is essential.

3. Classification of Potential Health and Safety Hazards

Health and safety hazards can be subdivided into three major areas: physical, chemical and biological.

Physical hazards would include radiation (ionizing and non-ionizing), noise, vibration, thermal extremes, magnetic fields, pressure variations and other aspects of the working environment.

Chemical hazards would include substances or compounds specifically identified (or identifiable), whether pure, impure or present in a mixture. There are many ways of classifying chemicals based on their physical properties, elemental nature,.structure, etc. A classification system should take into account the properties, major route(s) of exposure and absorption and biological effects of the chemicals. It is possible to develop a table to identify those body systems that should be monitored or evaluated medically when there is a potential for exposure to a specific chemical, e.g. a person working with mercury would have levels of mercury in urine and blood monitored at intervals.

Biological agents include whole animals, parasites and all micro-organisms, whether pathogenic to man or not. There are many potential hazards in the care and handling of animals and cellular cultures. For workers known to be at special risk, e.g. from rabies, Marburg virus or malarial parasites, an appropriate health examination and immunization are warranted. For all persons at risk, appropriate emergency procedures to be followed in case of any accident should be established.

4. Co-operation

Once the worker enters the laboratory workplace, he or she must co-operate with all other employees and management to ensure implementation of safe working practices. The philosophy of Ontario's *Occupational Health and Safety Act* is relevant: practical co-operation is necessary by all parties. This co-operation may involve the formation of a health and safety committee, with equal representation from workers, union and management.

Health and safety committees should have the responsibility for identifying actual and potential problems. They may recommend preventive action and formally request management to act on their recommendations. The committee should have access to expert advice, training programs should be available to all members, and membership of the committee should be limited in time to ensure rotation of staff.

5. Education

Education for each employee in health and safety aspects of laboratory work should be a continuous process. The emphasis in the workplace should be positive, i.e. what is the correct way to do the experiment without immediate

injury to oneself or others and with due care to avoid long-term health hazards.

A worker should be encouraged to adopt a positive attitude towards safety and the prevention of accidents and to develop an ability to identify potentially hazardous situations. A first step is to know the nature of the health hazard posed by those chemicals or materials with which they would be working. Specialized courses in areas of occupational health and safety should be taken by employees to reinforce good working practices and to foster vigilance and alertness.

6. Monitoring the Workplace Environment

Assessment of the potential and actual hazards to health in a laboratory is a difficult task. Diagnostic laboratory work may involve the use of a limited number of chemical compounds over long periods of time. However, research laboratories often use a large number of chemicals over short periods of time. Monitoring the amounts of these chemicals in the workplace is frustrated by both the length of time they are in use and the presence of so many chemicals. In the case of one chemical being used in large amounts over the period of the working day, it is appropriate to apply existing exposure limits.

The greatest hazard posed by biological agents is infection. The type of infective organism(s) is often of greater significance than the amount or number of organisms.

Monitoring the amounts of hazardous chemicals in the workplace and the potential exposure of workers to these agents can be made less frustrating if all hazardous and potentially hazardous chemicals are segregated within the laboratory and, more importantly, if a log is kept that indicates the following:

- the amount of compound
- the date of arrival, opening and expiry of the chemical compound
- the hazardous properties of the chemical compound
- neutralization procedures
- the date, amount taken, and user whenever the chemical is drawn from the stock supply.

Code of Conduct Relating to Health and Safety in the Laboratory

Principle

Laboratories contain numerous hazards such as flammable liquids, infectious agents, toxic agents, radioactive

materials, open flames, compressed gases, electrical instruments, cryogens, glass, poisons, acids and caustics. A variety of individuals – employees, supervisors, students, visitors and patients – are exposed to some of these hazards in the laboratory. It is therefore essential that each laboratory develop, maintain and have in place an effective health and safety program. This Code of Conduct is intended to assist laboratory directors and managers in establishing effective and comprehensive health and safety programs. It is also intended to outline for all laboratory personnel the general terms of reference for healthful and safe practices in the laboratory.

Elements of the Code of Conduct

1. A Policy Statement from Senior Management
This written policy statement must be a clear, concise, sincere commitment to occupational health and safety and show clearly the development and maintenance of such measures. See Appendix A for a suggested statement.

2. A Joint Workable Health and Safety Program
A comprehensive, organized, health and safety program should be established. It requires active participation and co-operation of key people within the establishment. This program should include a health and safety committee as the major component in its makeup. To be effective this committee acts as a liaison between employees and management. It should act on behalf of employees to make management aware of particular hazards, problems or concerns. Equally, it should act on behalf of management to ensure that employees are aware of management efforts to provide a safe workplace. The activities of these committees should include:

a) identifying, defining and assessing/researching health and safety concerns;
b) reviewing organizational rules and regulations;
c) promoting and evaluating training and education in hazard recognition and control;
d) reviewing and investigating accident reports;
e) conducting workplace inspections;
f) establishing internal and external audits of laboratory health and safety activities.

3. A Site Specific Safety Manual
A specific written safety protocol consisting of rules, regulations and procedures should be developed and provided to each employee for each unique laboratory or

laboratory section. Together with statements of policy, these rules, regulations and procedures should constitute the Safety Manual. The manual must be concise, must be intelligible to everyone and must be available to all employees at all times. It should take into account acknowledged safe practices and relevant legislative regulations concerning fire, waste disposal, sanitation and workers' health, safety and compensation.

The rules and regulations within the Safety Manual should encompass the following as site specific objectives:

a) an educational program for staff;
b) assuring compliance with all legislative requirements regarding dangerous drugs, infectious agents, radioactive material, hazardous chemicals or reagents;
c) defining an on-site safety inspection program;
d) reviewing laboratory safety regulations every six months or more often if required;
e) maintaining records of all laboratory illnesses, incidents and accidents, and the corrective actions taken.

The Working Group considers that each laboratory should have the following philosophy clearly expressed within the Safety Manual: If the job cannot be done safely, then it should not be done at all.

4. Health and Safety Inspection

Regular safety inspections should be carried out to detect and report potentially unsafe situations or practices before accidents or illnesses can occur. Health and safety inspections should be conducted by in-house personnel; however, a part of the inspection system is envisaged as being an audit by an 'outside' agency. Each laboratory should have at least one employee with accreditation in laboratory health and safety. This person should be trained in preventive safety and in procedures to be followed in the event of an accident, e.g. basic first aid, cardiopulmonary resuscitation, spill clean-up, use of self-contained breathing apparatuses, etc. and should participate in laboratory inspections.

A Canadian Laboratory Health and Safety Accreditation program should be developed. Bases for programs of laboratory accreditation could be:

a) the Canadian Society of Laboratory Technologists laboratory accreditation program;

b) the American Industrial Hygiene Association laboratory accreditation program;
c) the Association of Official Analytical Chemists proposed accreditation program.

5. The Incident and Health Surveillance System

The recommendation of the Working Group is that an epidemiologist examine data of two basic types to identify health and safety outcomes and recommend improvements in existing work practices in the laboratory that would reduce or eliminate their recurrence.

The first set of data for this work would comprise an incident and accident surveillance system with a data collecting centre at Labour Canada and the second set is a medical surveillance system of laboratory workers with a data collecting centre at Statistics Canada (see Appendix B for details).

It is essential that: (a) the provinces and territories should be able to tap into both systems; (b) each reporting system should be nationwide, and (c) those provinces and territories that are not collecting data should begin as soon as possible.

6. Promotion of Health and Safety Awareness

A positive attitude towards health and safety must be adopted by everyone: staff, the health and safety committee and management. This should come through a constructive and reasonable approach, which should emphasize respect, caution, knowledge and common sense as well as an ability to respond to emergencies and crises. The greatest impact will come from good communications between management, staff and the safety committee.

The following are suggestions for the promotion of health and safety awareness:

a) A general awareness poster at the national level for laboratories (subject: Health and Safety).
b) Posters developed by local health and safety committees.
c) A newsletter by the health and safety committee for a set of laboratories and/or a selection in existing newsletters.
d) Specific motivational programs with awards and other forms of recognition for achievement in health and safety matters.
e) Seminar speakers specializing in health and safety.
f) Develop a symposium at the national level exclusively on laboratory health and safety. This might be incorporated into an existing symposium.

g) Infractions of safety protocol; involvement in accidents or incidents should be recorded in the file records. Union and management should be prepared to discuss appropriate disciplinary measures.

7. A Systematic Health and Safety Awareness Training Program

The health and safety committee should initiate and maintain a program that includes:

a) Participation in a basic training program of health and safety as a requirement for employment.
b) Advanced or special individual training for employees with specialized tasks.
c) Special in-depth instruction for key personnel such as supervisors, health and safety officers, fire marshals and any other such personnel who have responsibilities in an emergency.
d) Periodic updating in health and safety training, rules, codes of practice consistent with technological change.
e) Encourage laboratory health and safety training at secondary and post secondary education levels.

Existing laboratory health and safety courses include:

a) Annual Occupational Health and Safety Workshop Program, University College of Cape Breton, Chair – Occupational Health and Safety, Sydney, Nova Scotia, B1P 6L2.
b) 'The Hazardous Chemical Safety Seminar', J.T. Baker Chemical Company, Office of Safety Training, Phillipsburgh, New Jersey, 08865.

Appendix A
Suggested Policy Statement From Senior Management

A. It is the policy of the Department of _____ to provide sufficient resources to ensure that laboratories within its jurisdiction are designed, built and operated in a manner that will guarantee the prevention and control of personal injury, property damage and loss of health. The Government of _____ ranks safety and health equal to service to the public. It is the responsibility of all directors, managers, supervisors and all on-line staff to follow safety rules and regulations and to properly carry out the health and safety program.

B. It is the policy of the Minister of _____

Department to ensure that the laboratories within his/her jurisdiction are healthy and safe working places. It is the responsibility of all laboratory directors, managers, other supervisors and all other staff to implement and follow a safety program appropriate to the Code of Conduct.

C. From Page 1 of the Treasury Board of Canada's Handbook of Occupational Health and Safety.

Summary

'The provision and maintenance of working conditions and procedures which are conducive to the health and safety of employees is a prime requisite in the operation of the Public Service of Canada, and to this end, departments and agencies are responsible for implementing and maintaining safety programs appropriate to organizational, occupational and employee needs.'

Appendix B Suggested Epidemiological and Health Surveillance Systems

Part (i) Suggested Epidemiological Methods for the Implementation of a Canadian Survey

1. The Historical Prospective and the Case-Control Study Design

A study design that could prove useful in defining the health problems of laboratory workers in Canada is the *Historical Prospective Study* (Mausner and Bahn, 1974). The essential steps in this design are illustrated in Figure 1. Using workers employed in a hospital laboratory, as an

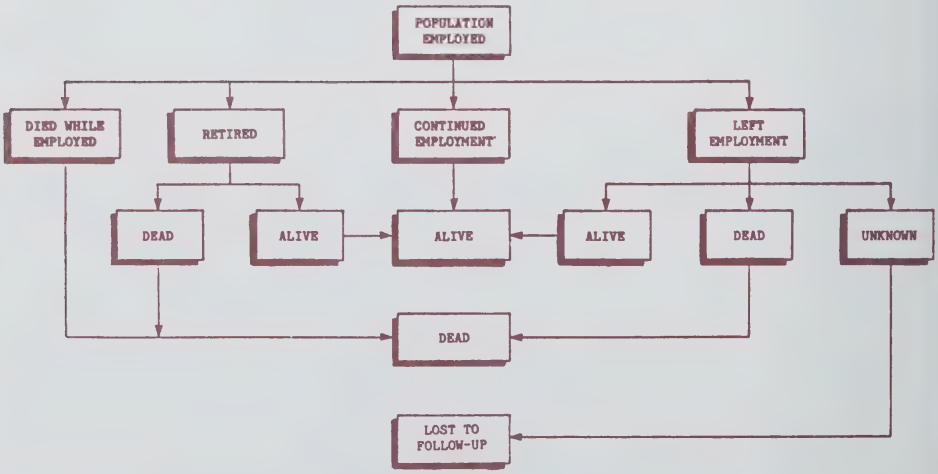

Figure 1. Plan for an Historical Prospective Mortality Study of Laboratory Workers

illustrative example, all employees at a specific laboratory are identified on a given date and then followed forward in time to determine their mortality rates. Comparison of this mortality rate with that of the general population or some other 'non-exposed' group would give an index as to whether there was any unusual mortality rate amongst hospital laboratory workers. Workers' Compensation records or accidents or Health Care Insurance morbidity data might be used with the same design to determine unusual causes of accidents or illnesses. The effectiveness of the cohort epidemiological approach has been well demonstrated by Doll (1955) and Selikoff (1964) in establishing the causal relationship between cancer of the lung and occupational exposure to asbestos.

Such an approach is feasible in Canada and is supported by the following publications. In 1974 Dr. Newcombe in a National Research Council of Canada publication described a method of 'record linkage' for following up large numbers of employees over long periods to detect and measure the delayed consequences of exposure to harmful agents in the working environment. In 1979, M.E. Smith, in a presentation at a conference in Ontario, described how use *may* be made of two of Statistics Canada programs in studying occupational exposure. These are the Canadian Mortality Data Base File and the National Cancer Incidence System. The minimum set of data required on each laboratory worker that would be entered into the cohort if such an approach is taken is:

- Full birth name
- Full birth date
- Full birth place
- Mother's/own maiden name
- Sex code
- Province of residence
- Last known alive date

Other useful items are:

- Place of residence
- Parental forenames and birthplaces
- Spouse's forenames
- Social Insurance Number
- Provincial Health Insurance Number

More recently Howe (1979) used a similar design to carry out a study of isoniazid exposure in tuberculosis patients and its correlation to mortality and cancer incidence.

As there is a National Health Insurance Program (NHIP) in Canada it may be possible, particularly at the provincial level, with a prospective study design, to examine morbidity patterns among laboratory workers to ascertain differences from the rest of the population or other specially selected comparison groups.

Although infectious diseases caused by viruses and bacteria are constant hazards for the medical laboratory worker, 60 years or more of research with oncornaviruses has so far failed to incriminate them in human cancer (Allen, *et al.* 1972). However, there is a growing body of evidence that indicates deactivation of cellular oncogenes by retroviruses and this can result in tumour formation (Land, *et al.* 1983). But it has been pointed out (McKinney 1980) that achieving containment of potential biological hazards requires an initial assessment of the risks to humans associated with materials and procedures employed while handling them. It is in providing estimates of risk of exposure that the proposed epidemiological studies of mortality and work related illness are most potent and hence recommended here.

The main shortcomings of this approach are that it requires large numbers of study subjects, is *costly* and requires a *long time* before answers are available. For example, identification of a cohort of 20,000 workers, each uniquely identified by name, date and place of birth and followed for five years, using only record linkage techniques, could cost about $10,000-$15,000. On the other hand, if the cohort had to be surveyed by mailing a questionnaire for details of occupational exposure and social habits the cost could approach $50,000-$60,000. For example, the cohort study that has demonstrated the utility and cost effectiveness that can be made of computerized record linkage for epidemiology in Canada has been recently reported (Howe, *et al.* 1979). This study followed a cohort of 41,226 isoniazid exposed and 22,811 non-exposed patients who were admitted for treatment of tuberculosis and cost approximately $25,000-$30,000 for a search of the computer register used in the study.

2. The Case-Control Study Design

Another study design, which is usually less costly and requires less time and number of subjects, is the case-control study.

For example, the case-control study on fishing as a risk factor in cancer of the lip, used 366 cases and 366 controls and cost $21,681 (Spitzer, *et al.* 1975). Cole

(1977), in discussing the status and need of epidemiologic research concerning cancer and occupation, points out that few of these population-based case-control studies have been done, although they are useful and supplemental to the historical prospective study. In a later publication Cole (1979) describes the merits of this study design in elucidating rare diseases, particularly when they occur in special exposure groups.

The data bases and communications resources of professional organizations could be used in collaboration with federal-provincial authorities to mount either of the above-described study designs. The Canadian Society of Laboratory Technologists (CSLT), with a membership of approximately 20,000, represents medical laboratory technologists in public and governmental hospital laboratories, academic and research laboratories and the laboratory service industries. The society has demonstrated its commitment to laboratory safety in health services by its publication and wide distribution of a safety manual (Shearer, 1979). Since each of its members renews membership annually, mostly by reregistration, the CSLT, through its permanent national office, is in a unique position to identify and survey a significantly representative sample of Canadian laboratory personnel.

3. Surveillance

Langmuir (1976), in a paper honouring William Farr as the founder of The Modern Concepts of Surveillance, made the following point: 'The methodology includes systematic collection of relevant data and their constant evaluation and dissemination to all who need to know.' It is this underlying concept of surveillance that must be at the heart of any proposed program for the surveillance of the health of laboratory workers in Canada.

To meet this requirement the basic set of relevant data that must be collected on each laboratory worker is:

- Birth date
- Full birth name
- Full birthplace
- Mother's/own maiden name
- Sex code
- Preplacement health examination
- A periodic health examination (Periodicity being determined by the nature of the exposure)
- A complete work history including dates of commencement and termination of each job and specific duties performed

- A unique identification number for each worker
- Company or laboratory population statistics.

Another useful item of information is:

- Reproductive histories

Constant evaluation of the data and dissemination of the information should be the responsibility of a national organization such as the Occupational Health and Safety Division of the federal government. As far as we know, it may require some form of provincial legislation to make the collection of needed data mandatory.

Part (ii) Elements of a Medical Surveillance Program for Laboratory Workers

A medical surveillance program for laboratory workers should consist of the following parts:

1. An initial examination
2. The periodic examination
3. A preplacement examination
4. Special examination.

It should be designed so that it is possible to detect relatively minor changes in health status that could reflect the onset of occupational disease at a reversible stage.

The Initial Examination
The initial examination, which is conducted prior to employment in a laboratory facility, is intended primarily to serve as a baseline from which deviations that may herald the onset of disease will be readily apparent. An example of a basic medical examination of this type is given below:

- complete physical, including ECG, chest X-ray, lung function tests
- audiometric measurements
- biochemistry – routine checks, including liver function
  - special checks if appropriate in relation to the work to be performed (e.g. blood lead if lead exposure, etc.)
  - complete blood count
  - assessment of mental health
  - review of immunization status
  - review of allergies, skin problems

It may be helpful for the examining physician to have access to personal medical records at this stage.

It should be noted that, although this kind of examination is frequently referred to as a pre-employment examination, several months may pass before the initial examination is completed.

If the examining physician is intimately acquainted with the operation of a particular laboratory, he may add to the basic examination or emphasize certain aspects. However, in general, the examining physician is unlikely to have more than a passing acquaintance with the operation of a particular laboratory and will require guidance and assistance in determining the appropriate tests to be conducted and the organ systems likely to be affected. The necessary information can probably be supplied by the director of the laboratory facility in a small or medium sized operation and by the immediate supervisor in a larger organization. Some unique hazards associated with laboratory operations have been well documented. The designation 'laboratory worker' embraces a variety of occupations with varying backgrounds and knowledge of the hazards, real or potential, associated with laboratory operations.

A medical surveillance program with examination and testing will build upon the basic example and be modified to meet the unique requirements of a particular facility.

2. The Periodic Examination

The periodic examination permits an evaluation of the health status of the employee and allows the examining physician to compare findings with those of the initial examination. It also provides an opportunity for health education and health promotion. As a disease preventive measure, it has merit whether or not the disease is associated with or caused by occupation.

Of great help to the examining physician would be a record of the frequency, extent and nature of the exposure to specific hazards and information on working environment surveillance. Although not specifically designed to do so, physical and laboratory findings can, and frequently do, support or negate the results of environmental monitoring. They also confirm the adequacy of laboratory techniques or procedures or indicate a need for modification or revision.

The frequency with which laboratory workers are examined and biological specimens taken will vary with the nature of the risk associated with laboratory work. Accurate risk assessment of a particular laboratory will

require the utmost co-operation between the laboratory director and the examining physician.

In a research establishment, with exposure to some of the less well-known toxins and chemicals, monthly examination of biological specimens may be necessary and a more detailed physical examination, with emphasis on the organ systems likely to be affected, at three to six-month intervals. Where the exposure has been to a substance that can produce first effects well into the future, such as a carcinogen, the information should be prominently displayed on the medical documents of the employee and the records should follow the employee to new or changed employment.

3. Preplacement Examinations

There may be a variety of hazards within a laboratory, and exposure can vary with the job being performed. If, for example, a worker is transferred from one job to another, there may be sufficient change in the nature of the hazard to require a repeat examination. An individual found fit for one job may not qualify medically for another job in the same laboratory. The specific details of the examination and the hazards likely to be encountered in a new assignment should be a topic for discussion between the laboratory director and the examining physician.

4. Special or Unscheduled Examinations

If, during employment, an unpredicted or unscheduled incident occurs that may have resulted in an unusual exposure or if the employee has reason to believe his health is being adversely affected by his work, a repeat examination is indicated. The unscheduled examinations can occur and be repeated at any time in the course of employment.

Résumé

Reconnaissant le fait que les travailleurs de laboratoire sont exposés à des risques plus élevés qu'on ne le croyait auparavant, le Comité consultatif fédéral-provincial sur l'hygiène du milieu du travail a mis sur pied le *Groupe de travail sur la surveillance de la santé et de la sécurité dans les laboratoires*. Ce rapport est le fruit des délibérations du groupe de travail, dont les membres se sont rencontrés entre octobre 1982 et octobre 1983. On s'attend à ce que ces directives à l'intention des travailleurs de laboratoire énoncent des principes généraux pour tous les employés de laboratoire en vue d'améliorer la santé et la sécurité dans ce milieu de travail.

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A Guide for Joint Health and Safety Committees and Representatives in the Workplace	$1.00

News and Notes

Ventilation '85
1st International
Symposium
on Ventilation Control

This conference, held in Toronto from October 1 to October 3, 1985, was attended by about 325 delegates from various parts of the world.

Following the plenary session on the first morning of the conference, up to three concurrent sessions were held. Papers were divided into categories – Advances in Tracer Gas Use; Ventilation Control of Toxic and Explosive Contaminants; Advanced Development in Ventilation; Ventilation for Residential and Modern Office Buildings; Advances in Local Exhaust Technology; Ventilation for Control of Carcinogens and Bio-hazards; Ventilation Measurements and Control, Filters, Air Recirculation and Energy Conservation.

Many of the papers presented up-to-date information on the current state of industrial ventilation. For example, in the plenary session, speakers discussed the 'K factor' in the general ventilation equation as being too broad; the use of water model testing for the development of efficient general ventilation systems; and factors to be considered for efficient laboratory fume-hood design. During the concurrent sessions, several papers suggested that the exhaust criteria recommended by the ACGIH Ventilation Manual were too high, as lower flow rates have been found to be sufficient for control of contaminants.

A number of papers were presented on Indoor Air Quality, and the following facts emerged:

(1) Ventilation provided for indoor air quality must satisfy thermal requirements as well as respiratory requirements for O_2 and CO_2.
(2) There are neither reliable sampling methods for micro-organisms nor allowable exposure guidelines.
(3) A CO_2 concentration of 1,000 ppm is gaining wide-spread acceptance as an indirect indicator of indoor air quality.

Several papers were presented on the tracer gas technique for measuring infiltration, air distribution, hood capture efficiency testing and model testing.

A number of papers discussed case studies involving

metal plating and cleaning operations, the semi-conductor industry, automotive paint booths, screen-printing plants, air curtains, computer simulation and push-pull ventilation.

Of the 60 papers presented, 75 per cent were from Canada and the United States, and the remainder from Europe and Japan. Of the European contributions, more than half came from Britain and France.

Judging by the comments of the delegates and the quality of the presentations it was apparent that the symposium achieved its goal of providing an opportunity for international representatives to exchange scientific information in the ventilation field in a very well-organized manner.

Air Pollution Control Association – Ontario Section and the Pollution Control Association of Ontario 1986 Joint Annual Conference

The 1986 Joint Annual Conference of the Air Pollution Control Association – Ontario Section, and the Pollution Control Association of Ontario, will take place in the Hamilton Convention Centre on April 27-29, 1986.

The Honourable Jim Bradley, Ontario Minister of the Environment, has been invited to be the keynote speaker. Joining him in the opening plenary session will be J. D. Kingham, Regional Director General of Environment Canada for the Ontario Region, James W. MacLaren, well-known consulting engineer and J. Walter Giles, Associate Deputy Minister, Ontario Ministry of the Environment. Among the topics to be discussed will be areas of concern to the International Joint Commission, the Pearce Commission Inquiry on Federal Water Policy, and acid rain.

In separate techical sessions, APCA-OS will feature papers on Regulation 308, the air quality index and indoor air quality. PCAO will feature papers on remediation with respect to in-place pollutants and the upgrading of industrial and municipal facilities. The two societies will hold a joint session on hazardous waste management, including economics, PCB clean-ups and new regulations in Ontario.

For further information, please contact

Dr. H. G. McAdie,
H. G. McAdie Associates,
104 Golfdale Road,
Toronto, Ontario, M4N 2B7.
(416) 488-4912

Coming Events

April 27 - 29, 1986	Joint Annual Conference of the Air Pollution Control Association – Ontario Section, and the Pollution Control Association of Ontario, HAMILTON, ONTARIO. For further information contact: Dr. H. G. McAdie, H. G. McAdie Associates, 104 Golfdale Road, Toronto, Ontario. M4N 2B7. (416) 488-4912
April 27 - May 1, 1986	American Occupational Health Conference, DENVER, COLORADO. For further information contact: T. Forrest Fisher, M.D. (Program Chairman), General Manager/ Health Service, United Steel Corporation, 600 Grant Street, Suite 1332, Pittsburg, Pennsylvania 15230.
May 5 - 9, 1986	Institute of Environmental Sciences' 32nd Annual Technical Meeting 'Environmental Technology – Coming of Age' For further information contact: Douglas Mahn, Technical Program Co-Chairman, Thermotron Industries, 338 West 12th Street, Holland, MI 49423.
May 12 - 22, 1986	International Symposium on Biomedical and Cellular Indexes of Human Toxicity in Occupational and Environmental Medicine, MILAN, ITALY. For further information contact: Carlo Erba Foundation, Via Cino del Duca 8, 20122 Milano, Italy.
June 1 - 4, 1986	69th Canadian Chemical Conference University of Saskatchewan, SASKATOON, SASKATCHEWAN, CANADA.
June 5 - 6, 1986	Occupational Hazards in the Arts, SEATTLE, WASHINGTON. For further information contact: North West Centre for Occupational Health and Safety, Department of Environmental Health, SC - 34, University of Washington, Seattle, Washington, 98195.
June 13 - 16, 1986	86th Annual Meeting of the Canadian Lung Association, and the Annual Scientific Meetings of the Canadian Nurses' Respiratory Society and the Physiotherapy Section of the Canadian Lung Association, WINNIPEG, MANITOBA, CANADA. For further information contact: Canadian Lung Association, 75 Albert Street, Suite 908, Ottawa, Ontario. K1P 5E7. Tel: (613) 237-1208.

June 30 - July 2, 1986	Occupational Medicine Association of Canada, Annual Meeting, VANCOUVER, BRITISH COLUMBIA, CANADA. For further information contact: OMAC, c/o Div. of Occupational and Environmental Health, Mather Building, 5804 Fairview Avenue, University of British Columbia, Vancouver, B.C., V6T 1W5.
July 14 - 18, 1986	Environmental Effects on Human Performance Standards and Protection. Main areas of interest – thermal environment and standards, with a special focus on clothing and protection. For further information contact: Dr. Igor Mekjavic, Kinesiology Department, Simon Fraser University, Burnaby, B.C., Canada, V5A 1S6.
July 21 - 25, 1986	Fourth International Congress of Toxicology, TOKYO, JAPAN. For further information contact: Fourth International Congress of Toxicology Hongo, P. O. Box 45, Tokyo, Japan.
August 3 - 9, 1986	International Symposium on Natural and Man-Made Hazards, RIMOUSKI, QUEBEC, CANADA. For further information contact: Dr. Mohammed El-Sabh, Département d'Océanographie, Université du Québec à Rimouski, 310, avenue des Ursulines, Rimouski, Québec G5L 3A1. Tel: (418) 724-1755
August 10 - 14, 1986	International Conference on Safety and Health at Work, ADELAIDE, SOUTH AUSTRALIA. For further information contact: Mr. Bill Embling, Conference Secretariat, 'Safety and Health at Work' Conference, GPO Box 465, Adelaide, 5001, South Australia.
September 15 - 19, 1986	Fifth International Symposium on Loss Prevention and Safety Promotion in the Process Industries, CANNES, FRANCE. For further information contact: Societe de Chime Industrielle, 28 Rue Saint-Dominique, 75007 Paris, France.
September 16 - 19, 1986	Medichem '86 Fourteenth International Congress on Occupational Health in the Chemical Industry, LUDWIGSHAFEN, GERMANY. For further information contact: Professor A.M. Thiess, Corp. Medical Director, Basf, Aktiengesellschaft, D-6700, Ludwigshafen, FRG.
September 28 - October 1, 1986	2nd International Conference on the Combined Effects of Environmental Factors, KANAZAWA, JAPAN. For further information contact: Conference Secretariat, c/o Department of Public Health, School of Medicine, Kanazawa University, 13-1 Takaramachi, Kanazawa, 920 Japan.

October 8 - 10, 1986	International Conference: Occupational and Environmental Significance of Chemical Carcinogens, BOLOGNA, ITALY. For further information contact: M. A. Mehlman, North American Regional Secretariat, 7 Bouvant Drive, Princeton, New Jersey, 08540.
October 20 - 22, 1986	Frontier Health and Safety, Ottawa Congress Centre, OTTAWA, ONTARIO, CANADA. For further information contact: Mr. K. A. Oakley, First National Health and Safety Symposium, P.O. Box 5218, St. John's, Newfoundland, Canada, A1C 5W1. (709) 726-7270
May 24 - 30, 1987	ILO's 11th World Congress on the Prevention of Occupational Accidents and Diseases 'Co-operation Towards a Better Working Environment: The Future of Safety and Health at Work', STOCKHOLM, SWEDEN. For further information contact: Swedish Organizing Committee, Post Box 22236, S-104 22, Stockholm, Sweden.
September 27 - October 2, 1987	XXII International Congress on Occupational Health, SYDNEY, AUSTRALIA. For further information contact: The Secretariat, XXII International Congress on Occupational Health, G.P.O. Box 2609. Sydney, N.S.W., Australia 2001.

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